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Moving Object Detection and Tracking in Video Frame Based on OpenCV

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Abstract. Local occlusion may be developed during the target motion, such that it is urgent to solve the problem of video tracking loss caused by moving target occlusion. In this paper, the computer vision library OpenCV is used to preprocess the motion video frame. Two algorithms are combined to solve the problem of tracking loss due to target-background similarity and occlusion: one is the Camshift algorithm (which is used to track the moving target); the other is the Kalman filter (which is used to predict the target position). Comparing with Meanshift algorithms in the same experimental environment, the results show that the proposed Camshift-based method can effectively filter out the background interference in the tracking process based on accurate detection and tracking of moving targets, and make the motion information of occluded targets more prominent. Good performance has been achieved in the interference and occlusion environment, and it has certain real-time performance and effectiveness.

Keywords. Moving target detection; Moving target tracking; OpenCV; Camshift; Kalman

1. Introduction

With the rapid development of computer vision, target detection, and tracking have become the focus of scholars in many fields, mainly used in intelligent video surveillance, transportation hub, petrochemical plant monitoring, and so on. Because the traditional moving target detection and tracking algorithm can not meet the requirements of speed and accuracy, and the amount of calculation is complex, the target tracking effect is poor. For example, Wu Feiyan [1] used the optical flow method to explore the target detection of moving images to obtain motion information, but the amount of calculation is large and susceptible to noise interference. Milin and Shankar [2] used bilateral filtering to preprocess the image, and used the optical flow method to calculate the volume motion vector to separate the target and background, which can reduce the impact on target detection to a certain extent. Le Ying and Zhao Zhicheng [3] used the background difference method to segment the background of the image sequence and the moving target, and realized the recognition and detection of multiple moving targets. Li Ning et al. [4] proposed a human motion detection algorithm based on background difference method to detect running targets.

At this stage, intelligent video surveillance is faced with real-time background updating, the effectiveness of moving target detection, and occlusion of moving targets,

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which leads to the lack of moving target tracking information and the failure of target tracking. Therefore, it is of practical application value to study and improve the moving target detection and tracking technology in video images. Intelligent video surveillance mainly extracts the target of interest from the actual surveillance video image, and realizes the semi-automatic or automatic tracking of the target. It has autonomy, real-time, effectiveness, and can complete tasks such as tracking pedestrians, vehicle.als, and monitoring [5]. It has certain application value and has received extensive attention and strong interest from researchers at home and abroad. Yan Yunyang [6] proposed an improved AdaBoost algorithm based on eigenvalue partition, and realized theoretical face recognition by linear discriminant analysis algorithm. Zhang [7] used the improved Vibe detection algorithm to accurately identify moving vehicles and perform automatic target tracking. Jiang [8] based on MeanShift and Kalman filter robust tracking algorithm research, can achieve the purpose of fast-tracking moving targets, with strong robustness. Wang et al. [9] proposed a robust tracking method based on saliency to solve a series of problems in complex scenes such as clutter, interference, and partial occlusion. Xiao et al. [10] verified the Kalman filter and multi-cue fusion tracking algorithm on different infrared image sequences, which can effectively improve the robustness and accuracy of small target tracking. Based on OpenCV, Wang et al. [11] used the image processing technology combining K-means clustering algorithm and Canny edge detection algorithm to detect the edge of the target, which enhanced the recognition of the target edge contour and the extraction of image features to a certain extent. However, the algorithm is too complex and has poor accuracy.

Given the above problems, this paper mainly focuses on the two aspects of moving target detection and target tracking in video sequences under static background. In this paper, Pycharm and OpenCV are used to build a development platform to study the detection of moving targets in video sequences, which is used to solve the problem of moving target tracking loss. Camshift algorithm combined with Kalman filter is mainly used to correct and track the position of moving targets. Finally, the effectiveness, robustness, and real-time performance of the algorithm are verified by comparing with the original algorithm.

Specifically, the main research work of this paper is divided into five sections: Section 2, through the video image preprocessing, the median filtering algorithm is selected to remove the noise problem in the image transmission process; image binarization and morphological dilation are used to reduce the interference of background in detection and tracking. In section 3, the Meanshift and Camshift algorithms are briefly analyzed, and the Kalman filter is introduced to optimize the tracking algorithm. In section 4, the proposed algorithm and Camshift algorithm are compared and analyzed in the same experimental environment to verify the effectiveness of the proposed algorithm. In section 5, the research contents of this paper are summarized, and the shortcomings of the algorithm are analyzed as the next stage of research work. It has been verified that this paper takes into account the accuracy and real-time performance in the detection and tracking of moving targets.

2. Video image Preprocessing

To improve the quality of image data and the accuracy and effectiveness of moving target detection [12], it is necessary to preprocess the video image sequence of moving targets in fixed scenes. In this paper, the moving target video image preprocessing, including image filtering denoising, image binarization, and morphological expansion processing.

2.1. Image Denoising

Image filtering is the primary task of video processing. In the process of video image information transmission, it is often affected by noise, which is prone to data loss, thus reducing image quality. In view of this, this paper uses OpenCV-based median filtering method to reduce noise and ensure the quality of video images.

The median filtering algorithm is a nonlinear filtering algorithm, which can better suppress noise, preserve the details of the image, and overcome the problem of image blurring caused by mean filtering [13]. The essence of filtering is to sort the values of each point in the field of a certain point in the image sequence according to the size of the gray value and select the intermediate value as the new pixel value [14]. Specifically, the median filter shown in (1) can be selected to obtain the median filtered image :

$$y_{(x_1,x_2\cdots\cdots x_k)}=median(x_1,x_2\cdots\cdots x_k) \tag{1}$$

In the formula, let$(x_1, x_2 \cdots\cdots x_k)$be the pixel point in the sliding window, and k is the number of pixels in the sliding window.

In this paper, two different environments are selected to identify and track moving targets. The effect of filtering is shown in Figure 1 and Figure 2. In Figure 1 and Figure 2, Figure (a) is the original image, Figure (b) is the image after adding noise, and Figure (c) is the effect image after median filtering. From the diagram, it can be seen that in the case of moving targets with or without occlusion, the use of median filtering shows a good noise reduction effect and meets the basic requirements of the experiment.

(a) Original image (b) After adding noise to the image (c) Median filtering effect

Figure 1. Moving target unoccluded filter processing diagram

(a) Original image (b) After adding noise to the image (c) Median filtering effect

Figure 2. Moving target has occluded filter processing graph

2.2. Binarization and Morphological

To reduce the interference of the background on the detection target and highlight the location of important information, the image sequence is binarized. The key to image binarization is the selection of threshold value. If the gray value range of the image is [0,255] and the binarization threshold is set$T(0 \leq T \leq 255)$, the binary image $R(x,y)$ [15]is obtained. The general formula for binarization is shown in (2).

$$R(x,y) = \begin{cases} 255, & f(x,y) \geq T \\ 0, & f(x,y) < T \end{cases} \tag{2}$$

In the formula, $f(x,y)$is the pixel gray value at point (x,y) before the original image processing.

Because there are some holes and fractures in the moving target in the binary image, this paper uses morphological expansion to further process the image based on binarization. The essence of morphological expansion is the process of finding the local maximum value of the image, and expanding the highlighted part of the image. By extracting the moving target information in the video image, the current situation of voids and fractures can be effectively improved [16]. By expanding the input image $src(x + x_1, y + y_1)$, the expression of the output target image $dst(x,y)$ is shown in (3).

$$dst(x,y) = \max_{x_1, y_{1:ele(x_1,y_1) \neq 0}} src(x + x_1, y + y_1) \tag{3}$$

In the formula,$(x + x_1, y + y_1)$ represents the coordinates of the pixels in the surrounding area of pixel(x,y).

The effect of binarization and morphological dilation is shown in Figure 3 and Figure 4. In Figure 3 and Figure 4, Figure (a) is represented as the original image, Figure (b) is represented as the effect of binarization processing, and Figure (c) is represented as the effect of morphological expansion. It can be seen from Fig.3 and Fig.4 that the binary image has some incomplete target information, which has a certain impact on the recognition and tracking of moving targets. Through the expansion processing, it can be clearly seen that the method can fill and connect the holes and cracks in the moving target, and the highlighted area is obviously increased, paving the way for the subsequent detection and tracking of moving targets.

(a) Original image (b) The effect of binarization treatment (c) The effect after expansion

Figure 3. Moving target unoccluded filter processing diagram

(a) Original image (b) The effect of binarization treatment (c) The effect after expansion

Figure 4. Moving target has occluded filter processing graph

3. Moving target Tracking Algorithm and Optimization

Moving target tracking is a process of processing video sequence images based on moving target detection. It mainly analyzes the data information of moving targets, matches the coordinates of similar images with targets in continuous video sequence images, and continuously obtains the actual position of moving targets.

3.1. Moving Target Tracking Algorithm

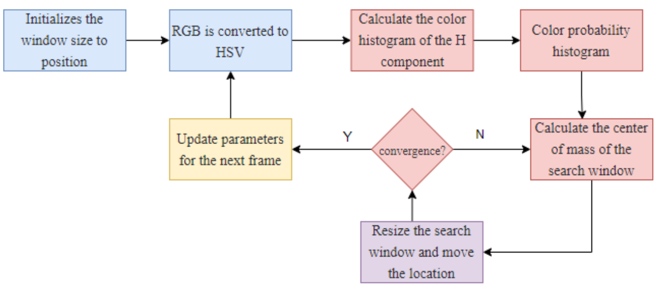


Figure 5. Camshift tracking algorithm flowchart

The commonly used moving target tracking algorithms have different accuracy and robustness in different environments. Meanshift and Camshift algorithms are commonly used target tracking algorithms in video surveillance [17], which have better tracking effects for simple and unoccluded moving objects. Meanshift is also known as mean shift. The essence of the tracking algorithm is that it does not require any prior knowledge and depends entirely on finding the densest area in the image. The advantage of Meanshift is that the algorithm is simple and easy to implement, and has a good tracking effect on manually selecting the target in the search window.

Since the Meanshift algorithm keeps the window size unchanged during the tracking process, the algorithm converges too slowly, which can only reflect the rough position of the sample point distribution and cannot achieve accurate tracking of moving targets. The Camshift algorithm is further optimized as the Meanshift algorithm. The principle of the algorithm is to perform Meanshift algorithm operations on all image frames in a continuous video image, and use the target centroid of the previous frame as the centroid of the current frame. In the iterative operation, the tracking of the moving target is completed. Camshift tracking algorithm flow chart is shown in Fig.5.

The specific implementation process of the Camshift algorithm is as follows: To determine the size and position of the initialization window. Because the change of illumination will affect the RGB color image in the surveillance video image, the image is converted from RGB to HSV color space, which is convenient for the tracking effect to be more significant. The H component in HSV is calculated as histogram. The probability of the value of each pixel in the video image is replaced by its corresponding color, and the color probability histogram is obtained as the input of the Meanshift algorithm. Let the point of the search window be (x, y), $\delta(x, y)$be the pixel value of (x, y), and calculate the zero-order distance $M_{00}$and the first-order distance M_{10},M_{01}[18] [18]of the window, as shown in formulas (4) and (5):

$$M_{00} = \sum_x \sum_y \delta(x, y) \tag{4}$$

$$\mathrm{M}_{10} = \sum_{\mathrm{x}} \sum_{\mathrm{y}} \mathrm{x}\delta(\mathrm{x}, \mathrm{y}), \mathrm{M}_{01} = \sum_{\mathrm{x}} \sum_{\mathrm{y}} \mathrm{y}\delta(\mathrm{x}, \mathrm{y}) \tag{5}$$

Calculate the coordinates of the centroid of the search window (x_c, y_c) according to the algorithm shown in Equation (6) ;

$$x_c = \frac{M_{10}}{M_{00}}, y_c = \frac{M_{01}}{M_{00}} \tag{6}$$

And search window size W is adjusted according to the pixel value press (7).

$$w = \frac{M_{00}^{\frac{1}{2}}}{256} \tag{7}$$

The distance from the window center to the centroid is compared with the preset threshold. If the moving distance between the two is greater than the preset threshold, the window center is recalculated and adjusted, and the moving target is gradually approached through continuous iterative operations until the preset threshold is met. The obtained window size and centroid are used as the initial values for updating the next frame. The algorithm solves the disadvantage that the search window size cannot be adjusted in the Meanshift algorithm. It can adaptively adjust the search window size with the moving target and perform real-time tracking, and has a good tracking effect on the deformation of the moving target.

3.2. Fusion Based on Kalman Filter and Camshift Tracking Algorithm

In practical applications, when the moving target has obvious morphological changes, partial occlusion or full occlusion, the computational complexity of the Camshift algorithm will be greatly improved, thereby reducing the computational efficiency, and the target tracking may fail, which cannot be applied to the intelligent monitoring video platform.

To solve the above problems, this paper combines the effectiveness of Kalman filter algorithm prediction to predict the position of the moving target at the next moment. Because the Kalman filter sets the initial velocity of the moving target to 0, there is a certain error with the actual target velocity. The Camshift algorithm is used to update the Kalman filter to complete the correction of the moving target velocity.

The essence of Kalman filtering algorithm is to establish the state equation and observation equation of the system, estimate the state of the target at the next moment, and complete the process of target tracking by continuously predicting and updating the system parameters. The system state equation and observation equation are shown in equations (8) and (9).

$$x_{k+1} = F_k x_k + w_k \tag{8}$$

$$y_{k+1} = H x_{k+1} + V_{k+1} \tag{9}$$

In the formula, x_{k+1} and x_k represent the state vector at k + 1 and k respectively ; y_{k+1} represents the observation vector at time k + 1; $F_k$is the state transition matrix ; H is the observation matrix ; w_k and V_{k+1} are the state noise and observation noise in the system respectively. Since w_k and $V_{k+1}$are Gaussian white noises, their covariance matrices Q and R are defined as shown in (10) [19].

$$Q = diag\{1,1,1,1\}, R = diag\{1,1\} \tag{10}$$

The specific tracking workflow is as follows :

(1) Parameter initialization

The Kalman filter system state X is defined as $x_c = (x_c, y_c, vx_c, vy_c)$ and the observation vector $y_c = (x_c, y_c)$, (x_c, y_c) is the position coordinates of the moving target on the x and y axes, and vx_c, vy_c represents the speed of the moving target in the x and y directions. Let the initial velocity of the moving target be 0, then the state transition matrix F_k and the observation matrix H are defined as shown in (11).

$$F_k = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, H = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}^T \tag{11}$$

(2) Prediction

When the Camshift algorithm has obvious target morphological changes or severe occlusion, the Kalman filter is used to predict the position of the next frame. Let the optimal estimation value of the current k-time state x_k be $\hat{x}_{k|k}$, and first calculate the current moment. The predicted value of state x_k at the next moment $\hat{x}_{k+1|k}$, as shown in Formula (12) :

$$\hat{x}_{k+1|k} = F_k \hat{x}_{k|k} \tag{12}$$

The sign $P_{k|k}$ is introduced to represent the error covariance at the current time k, and the initial value when k = 0 is set to 0 matrix. The prediction error covariance $P_{k+1|k}$ is calculated recursively according to Equation (13):

$$P_{k+1|k} = F_k P_{k|k} {F_k}^T + Q \tag{13}$$

The Kalman filtering algorithm predicts the target position of the next frame by the position information of the previous frame of the moving target, reduces the search area and improves the effectiveness of target tracking.

(3)Update

After using the Kalman filter algorithm or Camshift algorithm to complete the position prediction of the moving target, the centroid and size of the target searched in the previous frame are used as new observations to update the Kalman model parameters to improve the accuracy of the moving target position prediction. The gain K_{k+1} in k + 1 state is calculated by formula (14) and the error covariance $P_{k+1|k+1}$ at k + 1 time is obtained by formula (15):

$$K_{k+1} = P_{k+1|k}H^T(HP_{k+1|k}H^T + R)^{-1} \tag{14}$$

$$P_{k+1|k+1} = (I - K_{k+1}H)P_{k+1|k} \tag{15}$$

Where I is the unit matrix.

Thus, the optimal estimate $\hat{x}_{k+1|k+1}$ of k + 1 at the next time is obtained as follows (16) :

$$\hat{x}_{k+1|k+1} = \hat{x}_{k+1|k} + K_{k+1}(y_{k+1} - H\hat{x}_{k+1|k}) \tag{16}$$

Continuously loop steps (2)-(3) to complete the tracking of moving targets.

Based on the Camshift algorithm, this paper combines Kalman filter for target detection and tracking. The principle of target tracking is shown in Figure 6.

From the flow chart of the detection and tracking algorithm, it can be seen that after reading the video sequence, the search window and Kalman filter parameters are first initialized, and the Camshift algorithm is used to perform the Meanshift algorithm on each consecutive frame of image to obtain the optimal position of the target. By judging whether there is a large change in the shape of the moving target or the target is occluded, if not, the Camshift algorithm is used to calculate the new target centroid and size as the observation value to update the Kalman filter. When the moving target is occluded, the predicted value of the Kalman filter is used as the observation value, the Kalman filter parameters are updated, and the target position and size of the next frame are continuously predicted, and the real-time tracking of the moving target is completed through continuous iteration and update.

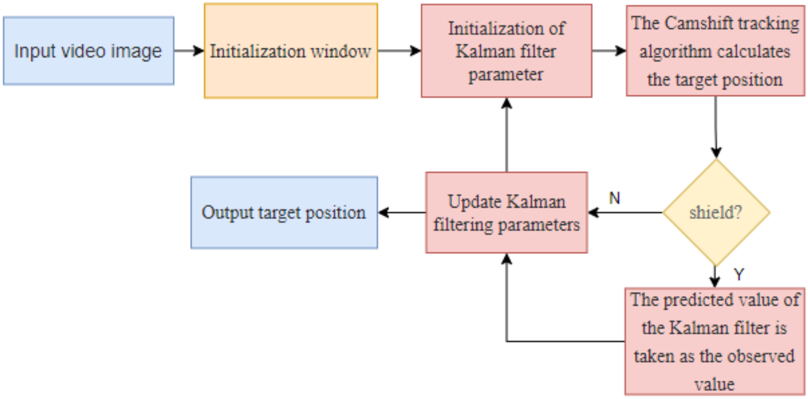


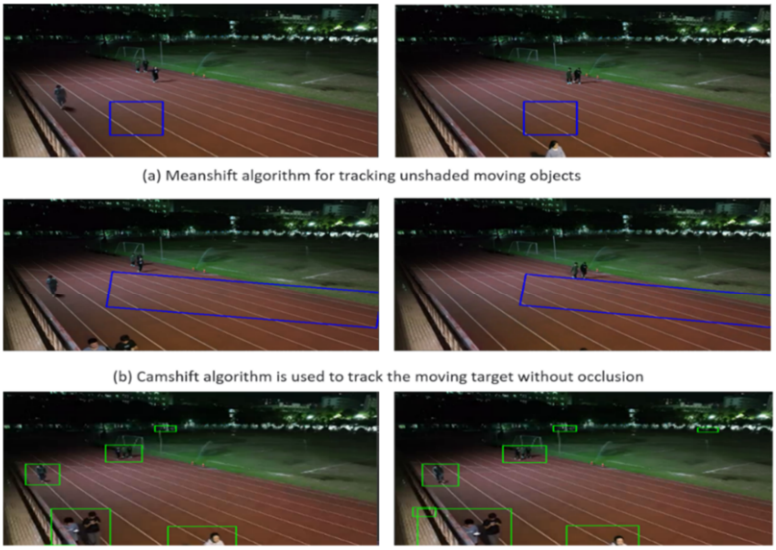
Figure 6. Flowchart of Camshift and Kalman tracking algorithms

4. Experiment and Result Analysis

To verify the effectiveness and real-time performance of the tracking algorithm proposed in this paper, two video sequences in different environments are selected, and the algorithm is compared with Meanshift algorithm and Camshift detection and tracking algorithm. The experimental environment is : python3.9 + OpenCV4.6.0, PyTorch deep learning framework ; the software development platform is window10 operating system. Hardware development environment : CPU is Intel (R) Core (TM) i9-10900K [20].

4.1. Analysis of Experimental Results of Unobscured Moving Target Tracking

The video sequence in Figure 7 is an experimental data set obtained by using DJI UAV for aerial photography. The moving target to be tracked is a moving pedestrian. The video sequence to be detected contains attributes such as background interference with morphological changes and moving very similar target colors. All algorithms are tested in the same experimental environment. The experimental results of the moving target in the video are shown in Figure 7. Fig. 7 (a), Fig. 7 (b) and Fig. 7 (c) are respectively represented as Meanshift algorithm, Camshift algorithm, Camshift combined with Kalman algorithm for unobscured moving target tracking experimental results. From Figure 7 (a), it can be seen that when the moving target moves, the Meanshift algorithm cannot adjust the size of the search window, resulting in target tracking failure ; it can be seen from Fig.7 (b) that the size of the search window can be adjusted based on the Camshift algorithm, but the target position at the next moment cannot be predicted, and the purpose of target tracking cannot be achieved. Figure 7 (c) is Camshift combined with Kalman algorithm for unobscured moving target tracking. When the moving target moves, the window size and position can be adjusted adaptively. Combined with Kalman 's prediction of the next state, the target position is corrected to complete the real-time tracking of the moving target.



(a) Meanshift algorithm for tracking unshaded moving objects

(b) Camshift algorithm is used to track the moving target without occlusion

(c) Camshift and Kalman algorithm are combined to track the unobstructed moving target

Figure 7. Video sequence 1 Moving target tracking effect

4.2. Analysis of Experimental Results of Occlusion Moving Target Tracking

The experimental video sequence of figure 8 is the selected video as the public video on the network as the data set of this experimental tracking. The video sequence to be detected contains two attributes of partial occlusion and complete occlusion. All algorithms are tested in the same experimental environment. The experimental results of moving target tracking in video are shown in Figure 8. Figure 8 (a) is the effect of Meanshift algorithm on the tracking of occluded moving targets. Figure 8 (b) is the effect of Camshift algorithm. Figure 8 (c) is the effect of Camshift combined with Kalman algorithm. After comparison, it can be seen that when the moving target moves, the Meanshift algorithm cannot iterate, and the window size remains unchanged, and the moving target cannot be tracked. Because the moving speed of moving target is too fast, Camshift algorithm can not locate the position of moving target, which leads to the failure of target tracking. When the moving target is partially occluded and fully occluded, the algorithm in this paper is used to track the occluded moving target. Combined with Kalman 's prediction of the next state, the target position is corrected. The optimized algorithm can effectively remove the interference of noise and background, and complete the purpose of moving target tracking, indicating that the algorithm in this paper has certain accuracy and real-time performance.

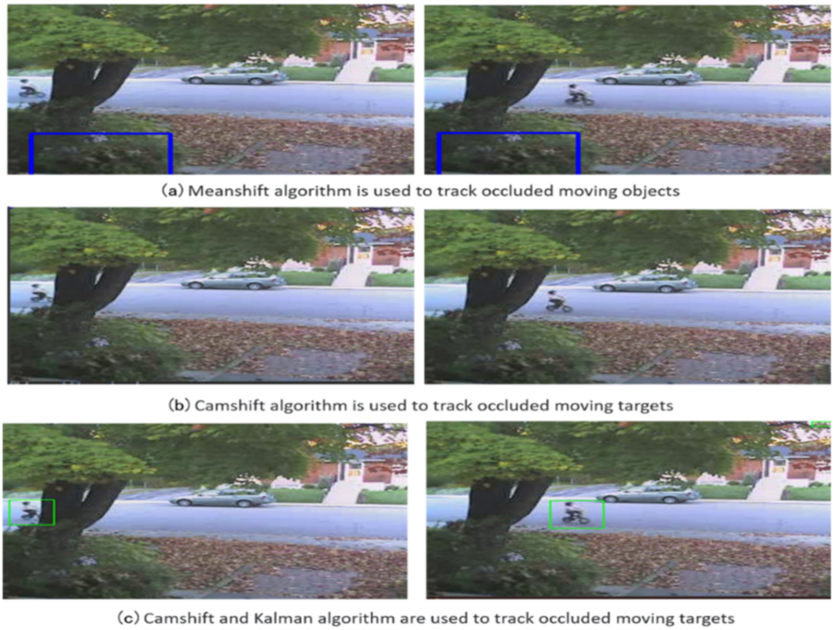


Figure 8. Video sequence 2 moving target tracking effect

From the analysis of the above experimental results, it can be concluded that the tracking algorithm based on Camshift and Kalman can track the target more accurately. Compared with the tracking experimental results of Meanshift algorithm and Camshift algorithm, the algorithm in this paper has the characteristics of accuracy and real-time performance, and better meets the requirements of moving target tracking in video sequences.

5. Conclusions

This paper studies and implements the detection and tracking of moving targets under the OpenCV open-source vision library. The purpose is to solve the problem that the target color of the moving target is similar to the background, and the target tracking loss exists in partial occlusion and complete occlusion. In this paper, the camshift algorithm combined with Kalman filter is proposed to predict the state of the next moment, to achieve the purpose of target tracking. This paper mainly introduces the basic knowledge of Meanshift algorithm and Camshift algorithm, and compares the experimental results based on Camshift and Kalman tracking algorithm.

The experimental results show that the algorithm can filter the interference noise generated during video transmission and reduce the interference of the background to the moving target. It has good performance and can effectively track the real-time target. This paper mainly focuses on the recognition and tracking of moving targets with single occlusion. However, in practical application scenarios, it is usually necessary to identify and track multiple moving targets. At this time, it is necessary to consider the factors such as mutual occlusion, stop or disappearance of multiple targets, which makes the tracking algorithm more complex.

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References

[1] WU feiyan. Moving Image Target Detection Based on Optical Flow Method. *Science & Technology Vision*, 2019;279(21):45-46.

[2] Patel M P, Parmar S K. Moving object detection with moving background using optic flow..*International Conference on Recent Advances and Innovations in Engineering*. 2014.

[3] Yue Ying, Zhao Zhicheng. Multi-moving object detection and segmentation based on background difference method. *Chinese Journal Of Construction Machinery*, 2020;18(04):305-309.

[4] Li ning, Huang shan, Zhang xianzhen, Li xiujun. Human Motion Detection Based on Background Difference. *Microcomputer Information*, 2009;25(21):257-258+282.

[5] Gao xaing. Research on moving target detection and tracking algorithm based on OpenCV . *Ningxia University*. 2019.

[6] Yan yunyang, Guo zhibo, Yang jingyu. Fast Face Detection Using AdaBoost Algorithm based Feature Value Division. *Journal of Chinese Computer Systems*, 2007; (11):2106-2109,.

[7] Zhang yufeng. Research on Detection and Tracking of Moving Vehicle Targets Based on OpenCV. *Anhui University of Science And Technology*.2018.

[8] Jang cheng. Research on dynamic target detection and tracking Algorithm based on Python+OpenCV. *Wuhan Polytechnic University*. 2019.

[9] Qi Wang,Shuangshuo Tang,Dingding Zhai,Xiaopeng Hu. Salience based Object Tracking in Complex Scenes. *Neurocomputing*, 2018;314:132-142.

[10] Sa Xiao,Yong Ma,Fan Fan,Jun Huang,Minghui Wu. Tracking small targets in infrared image sequences under complex environmental conditions. *Infrared Physics and Technology*, 2020;104(C):103102.

[11] Wang zhuangfei, Lu hailin, Geng wentao, Sun zaoqun. Research on Object Detection and Location System of fruit picking Robot based on OpenCV. *Electronic Technology & Software Engineering*, 2022;(02):137-140.

[12] Deng Yongkang. Development of tracking system based on OpenCV moving target detection. *Beijing University of Chemical technology*. 2021.

[13] Li chao. Research on moving object's detection and tracking Algorithm based on OpenCV. *Liaoning Technical University*.2015.
[14] Yan bin. Moving target capture and tracking Algorithm based on OpenCV. *Hebei University of Technology*.2018.
[15] Wang xueqing. Research and implementation of moving object detection and tracking algorithm based on OpenCV. *Northeastern University*.2015.
[16] Kumar Vinod,Singh Ravi Shankar,Dua Yaman. Morphologically dilated convolutional neural network for hyperspectral image classification. *Signal Processing: Image Communication*.2022.
[17] Yan aiyun. Intelligent detection and real-time tracking Algorithm of moving objects in complex scenes. *Northeastern University*. 2019.
[18] Yue bing. Research and implementation of detection and tracking moving object in image sequenc based on OpenCV. *Anhui University*.2016.
[19] Li Jianliang, Zhang Tingting, Tao Zhifei , Li Shuqing, Guo Qiurui . Pilot vehicle tracking algorithm based on improved Camshift and Kalman filter fusion. *Journal Of Electronic Measurement And Instrumentation*, 2021;35(06):131-139.
[20] Fatima Isiaka,Zainab Adamu. Custom emoji based emotion recognition system for dynamic business webpages. *International Journal of Intelligent Computing and Cybernetics*, 2022;15(4).